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ABSTRACT

A 1970 workshop that brought together academic and industrial engineers, sociologists, educators, and other behavioral scientists made some recommendations to universities, government, and industrial and professional societies concerning three major postulates. The postulates are that: (1) "public enlightenment on technology and how it interacts with the social system is long overdue," (2) "technical alternatives exist and must become a part of public decision-making," and (3) "the social and behavioral sciences eventually must become as familiar to engineering as physics, chemistry and mathematics." The discussion concerning each postulate is summarized by the editors, with excerpts from the reports of participants included to illustrate the diversity of opinion. Appendices contain a discussion of the organization of the workshop, including recommendations for persons organizing similar meetings; lists of participants; abstracts of the case studies (on transportation planning, the university and the housing crisis, new aspects for learning: how we shape tomorrow's society, nuclear power and its critics: the Cayuga Lake controversy and using technology to change society--a political problem) used to stimulate discussion; and abstracts of the three keynote addresses on the role of the university in educating engineers for solving societal problems. (AL)

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SOCIAL DIRECTIONS FOR TECHNOLOGY

SE 013 546

Memorandum of a Workshop
on
SOCIAL DIRECTIONS FOR TECHNOLOGY

Sponsored by
Commission on Education
National Academy of Engineering
2101 Constitution Avenue, N. W.
Washington, D. C. 20418

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FOREWORD

This Memorandum summarizes a workshop on social directions for technology, developed and sponsored by the Commission on Education of the National Academy of Engineering under a National Science Foundation grant. The Memorandum, which seeks to convey the flavor as ~~well as~~ the substance of the workshop by presenting alternatively selected quotations and a distillation of its conclusions and recommendations, was prepared by the participants themselves and not by the Commission. The Commission, nevertheless, subscribes to the views expressed in the Memorandum other than, of course, the quoted passages.

1. Origins of the Workshop

In 1961, the National Science Foundation sponsored a Conference on Engineering Education at Boulder, Colorado, to consider new directions engineering education could and should take. A major purpose of the Conference was to present recommendations and advice to the National Science Foundation. However, the Boulder Conference also produced another unexpected but significant result. This was the creation of the Commission on Engineering Education, which has, during the intervening years, been closely allied with the NSF from which it received generous support.

In 1968, the Commission on Engineering Education became affiliated with the National Academy of Engineering and changed its name to the Commission on Education. In recent years, as the Commission reviewed its goals and objectives for the decade of the '70's, it became overwhelmingly apparent that engineering education must incorporate in its concerns a new awareness of the relationship to the social sciences and the sciences of human behavior.

Although engineers have, almost from the beginning, used economics and the principles of the physical sciences in their plans and designs, only in recent years has the need to incorporate also the principles of the social and behavioral sciences become obvious. We need not enumerate the reasons for this emerging awareness. Suffice it to say that the engineering literature, the press, the media, the universities, politicians, students, all have decried our polluted environment, the present quality of life, the beleaguered cities, the population explosion and our future, which is sometimes represented as hopelessly bleak.

No small part of the blame for these disasters is laid at technology's door. The Commission on Education, therefore,

decided that they could render a valuable national service by holding a workshop for the purpose of determining -- with objectivity -- how education, and especially engineering education, could be refocused to make technology better serve the needs of society. In the words of the Workshop Planning Committee*:

> "The purpose of this Workshop is to develop strategies and mechanisms that will enable the university to participate effectively in making technology serve society."

Whether or not the Workshop met its objectives remains to be assessed. This Memorandum, however, does reflect quite accurately the many strong and unexpected opinions which arose from the Workshop.

2. Workshop Planning

Initial plans for the Workshop on the Social Directions for Technology were formulated by the Executive Committee of the Commission. They outlined the underlying philosophy of the Workshop when they wrote:

> "Science and engineering at this period in time can produce almost any given technological achievement or force nearly any change. However, in today's rapidly changing and growing society, technology can no longer be permitted to produce uncontrolled change. However, rational control is impossible without the universities and education taking new responsibilities in the service of society."

With this general statement as a guide, a group of engineers and social scientists were asked to plan a workshop that would seek answers to this question: What should be the new social directions for technology? This planning group, under the chairmanship of Dr. Richard Bolt, developed a program and procedures for the Workshop. They agreed to focus the Workshop around four specially prepared case studies of broad-based social problems: urban transportation, location of a power plant, housing, and educational systems. The plan was to utilize these cases as examples of the complex way in which technology and society intertwine.

Hopefully, focusing on these four areas would help the participants to characterize and classify broadly the kinds of socio-

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* The membership of this Committee is given in Appendix B.

technical problems with which the engineer must cope in the next decade. These case studies are summarized in Appendix D. More detailed accounts are available from the Commission on Education, National Academy of Engineering. Included, too, is a fifth background paper by Dean Brewster C. Denny entitled, "Using Technology to Change Society -- A Political Prøblem." While not a case study, it presents a challenging argument to the engineer on the need to understand the relationship between technology and political reality.

3. Workshop Participants and Their Disciplinary Background

One of the principal objectives of the Workshop was to bring together a group of participants from a broad spectrum of backgrounds and disciplines. This objective was achieved only in part, because many of the social and behavioral scientists invited were unable to attend. Consequently, the "disciplinary mix" resulted in a higher ratio of engineers than had been sought. The names and affiliations of the participants in the Workshop are listed in Appendix C.

4. Writing Efforts

Throughout the Workshop, various groups prepared written summaries of their conclusions and deliberations, which were compiled and disseminated to the participants. The diversity of viewpoints expressed in these papers made painfully clear that a universally acceptable summary of the Workshop's findings would be nearly impossible to fashion. Quotes from some of these have been incorporated into the Memorandum of the Workshop. The Commission submitted a first and then a second draft of this memorandum to the participants. This final version reflects the changes and criticisms they suggested and represents a digest of the vast amount of discussion that was generated.

5. Workshop Support

This Workshop was supported in part by a grant from the National Science Foundation under Contract NSF C-310, Task Order No. 182. It was held at Airlie House, Warrenton, Virginia, July 8-15, 1970.

SOCIAL DIRECTIONS FOR TECHNOLOGY

Memorandum of a Workshop

A TIME FOR CHANGE

In the past three decades, government, industry, social institutions, and educational establishments -- particularly schools of engineering -- have worked together to produce a technology resulting in a series of achievements unapproached in the history of civilization. Many of us have within our grasp material comforts more dazzling than anything we could possibly have imagined. Others of us live lives totally free from drudgery. We take for granted the fact that we are able to communicate instantly with each other from one end of the planet to the other, and to see events as they happen in other parts of the world. We can indulge in the excitement of long distance travel in short periods of time. We can press a button and our dishes are washed; we can turn a key and set into motion the complex workings of the internal combustion engine. The moon is no longer enshrouded in mystery; its beauty has been unveiled, its soil sampled, and its age revealed.

The promises of technology are as tantalizing as its pitfalls are foreboding: it provides us with the ability to change the character of our cities, to control the environment, to increase productivity, to augment leisure time, to extend the reach of

education, to produce more, better and less expensive health care, to provide better and lower cost housing, and to communicate instantly to any point on earth and in space. The challenge now is to realize this potential and to avoid the pitfalls. To achieve this, we must learn how to change the way government, industry, society, and education interact so that the energy, inventiveness, and commitment that produced a technology which met past needs can now produce a technology which, when properly applied, will meet the needs of the future -- a technology which can be totally compatible with man's desire to improve the quality of life.

As those who participated in the Workshop on Social Directions for Technology came to grips with the problem, it was clearly evident that:

FIRST: Our society, which is already placing demands upon the world's limited natural resources far out of proportion to our numbers, has begun to experience serious conflicts between our desire for "growth" and our aspiration for a viable environment.

SECOND: Decisions on issues in which technology is a major component are too often made on the basis of narrow self-interest, highly vocal and often irrational public opinion, and incomplete (although honest) information.

THIRD: Our present technological capability has been largely shaped by defense and space requirements and by a consumer-oriented market; as a result, social and environmental problems have been slighted.

FOURTH: There is a critical imbalance in the universities between the pursuit of knowledge for its own sake and research in ever narrowing areas, and the acquisition of understanding to increase one's ability to function in the real world and the practical application of research.

FIFTH: State and local governments (those branches which deal most directly with the public) have not effectively interacted with the university or industry. The noteworthy results occasionally realized, such as improved fire fighting capability, emergency medical services, and easier traffic flow, bear testimony to the potentialities of more effective interaction among them.

SIXTH: Our technological capability resides in our trained manpower -- yet major uncertainties exist about our policies for manpower utilization and needs for the future. The results are an unwillingness to capitalize on the adaptability of existing technological manpower, and an inability to predict which talents will be needed in the future.

The Workshop participants recognized that there are demands for change and that the pressures for change are insistent. For example, the public has become alarmed and acutely conscious of traffic congestion; of befouled lakes, rivers, and air; of power failures; and of diminishing natural resources. The public is alarmed, concerned, and determined to be involved in the decision-making processes that affect its environment and its daily life.

The elected representatives in government are responding to the public concern. Representatives in Congress have called for technology assessment. The Executive Branch has urged public discussion of emerging issues, many of which are inextricably entwined with technology.* There are signs of change in the pattern of federal support for engineering education; traditional research and discipline-oriented activities are being de-emphasized in

* Toward Balanced Growth: Quantity and Quality. Report of the National Goals Research Staff, Washington, D. C., July, 1970.

favor of mission-oriented projects such as those sponsored by the Department of Transportation and the Justice Department, agencies which in the past have not played a major role in sponsoring this kind of research. The National Science Foundation is emphasizing science for non-scientists and multidisciplinary research on problems of national need. Centers for research and development in environmental control, transportation, communication, and housing have been proposed in several quarters and, in particular, in the report to the President's Environmental Quality Council by the Office of Science and Technology.* A number of such centers have already been established.

In the universities themselves a wave of self-examination is resulting in a re-orientation of goals. Another significant force for change within the universities comes from the students themselves. Today's students have grown up in the television age; modern technology has brought national crises into their living rooms. Unfettered by economic pressure, many are demanding an education which will enable them to alleviate these problems -- an education that will have application to social and environmental problems.

Finally, significant pressures for change are being brought to bear on engineering schools by state and local governments

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* The Universities and Environmental Quality. A Report to the President's Environmental Quality Council. Executive Office of the President, Washington, D. C., September, 1969.

intent on utilizing technology for social benefit; by industry seeking ever-new uses for its technological capability; and by the university itself where the faculty, as well as the students, are anxious to see this country capitalize on its ability not just to produce a technology that can add not only to our material comforts, but its ability to apply it in a way that can maintain and even enhance the quality of life.

MEETING THE CHALLENGE

Meeting the challenge is of immediate urgency. It depends on more than changes in engineering education; it depends on new roles of the federal, state, and local governments by increasing their responsiveness to technological change; and it depends on new and strengthened relationships between industry and academia. The task is complex, largely because of the difficulty in comprehending the scope of and interactions of all the forces -- technical, social, economic, legal, religious, etc. It calls for a new interaction of engineering education with government and industry. To make this interaction effective, it was the consensus of the Workshop that certain postulates should be considered. These are set forth below.

I. PUBLIC ENLIGHTENMENT ON TECHNOLOGY AND HOW IT INTERACTS WITH THE SOCIAL SYSTEM IS LONG OVERDUE. The research capability and the technology are within man's grasp to make his life on this planet not only bearable, not only easier,

but more pleasant; that this has not been accomplished is due in part to the inertia (or rigor mortis) of our social and political institutions which need review and overhaul. The Workshop participants were convinced of the necessity for the enlightenment of the public and the involvement of the public in those issues in which technology plays a dóminant role. This requires, however, that the public understand modern technology and its relationship to society and the trade-offs required.

The University Can:

1. Develop and offer basic courses for all students at all levels -- from undergraduate to postgraduate and adult education -- which would ...

   .. explain the concepts of technology, e. g. modeling, feedback, and instability ..

   .. provide an understanding of the interaction of technology with the social system ..

   .. describe the risk-benefit relationships for decision-making.

The Government Can:

1. Encourage formal and informal programs designed to improve communication between technology and the public through financial and moral support, for dissemination in schools, citizens' groups, and the media.

2. Fund and encourage projects that will produce major changes in secondary school science education to foster an understanding of technology and its relationship to society.

3. Insure that its own public information programs describing the technology it supports convey an honest appraisal of the economic and social consequences of this technology.

Industry and the Engineering Societies Can:

1. Develop, support, and participate in programs to enlarge the public's understanding of technology, its limits, and its potential.

THE WORKSHOP PARTICIPANTS SAID ...

It is important that the general public have a greater appreciation for technology, particularly in the context of global, environmental and humanitarian considerations. There is an urgent need for engineering schools to participate in the education of all students and the general public.

High schools should offer programs in science and technology which would broaden student interest in improving the quality of life.

Other kinds of people -- politicians, financiers, economists, businessmen -- need to learn to work with technologists. They need to learn about technology just as much as engineers need to learn about sociology.

A most effective mechanism for reaching a wider public is the state-of-the-art book written by .... workers in the subject area under the guidance of a demanding worker-editor.

In today's technological world, a person is not 'educated' until and unless he has an appreciation and some understanding of what technology is and how it works. Therefore, all students should have studies (courses) in basic engineering and in socio-engineering that involve carefully selected case studies. Such courses probably do not exist today and should, therefore, be prepared jointly with social scientists. As a primer for such endeavors, the reader is referred to the Commission-sponsored text, THE MAN-MADE WORLD.

There is a need for non-engineering students to become broadly educated about contemporary technology: what it is, how it works, as well as its social and environmental consequences.

There is a vital need for the university to educate the public at large about key issues facing mankind: population growth, the gap between 'haves' and 'have-nots', environmental degradation.

In an era of an ecologically aroused public, there is real incentive to acquaint non-technically trained people with technology.

THE WORKSHOP PARTICIPANTS SAID ...

Courses should be developed (at the university level) for all students which will develop insight into (1) our techno-social system; its problems and constraints; (2) the interactions between technology and society; (3) bases of value systems and decision making; (4) limitations of a finite environment on a rapidly growing system; and (5) probable future developments. Similar efforts should also be undertaken for the general public at all levels from pediatric to geriatric with such information promulgated through all available media.

Develop adult education programs (including community colleges, extension programs, educational TV programs and on-the-job training) to provide the higher level of sophistication in the technological areas which will be needed by the labor force.

Establish an interdisciplinary committee on the university level to study, develop and conduct courses through the engineering college for non-engineers. Industry should coordinate with the university to establish engineer and non-engineer seminars of short duration. Industry should provide expenses and company time for such seminars.

New courses should be designed for the general public (including college students) to given them an understanding of technology and of the <u>real</u> rather than emotional alternatives it offers.

Many non-technologists have almost blind faith that technology can solve virtually any problem, once society determines a solution is wanted. Non-technologists (social scientists, etc.) need understanding of capabilities, limitations and means of assessing technological development.

II. TECHNICAL ALTERNATIVES EXIST AND MUST BECOME A PART OF PUBLIC DECISION - MAKING. They may be called "options" or "alternatives"; in either case, technological problems can usually be solved in more than one way. Therefore, those we have entrusted to choose the technology which is to enhance or improve our lives must have access to the technological alternatives available. Additionally, these decision-makers (often they are politicians), acting on our behalf, should be supplied ample information pertaining not only to the dollar cost of various technological alternatives, but also the cost to the environment, to the social system, and to the human condition.

There are many organizations that are capable of developing technical alternatives; many of these are also able to provide information on the interaction of these alternatives with the other parts of the social and environmental system. The university, however, is especially well equipped to provide these services since the development of the various alternatives could become part of its educational function. Nevertheless, it is well to remember that when the university or professional school provides service through research and development for an agency in the city, state, or federal government, it must maintain its tradition of political neutrality and intellectual objectivity; for example, it must exercise caution to insure that the alternatives proposed are not colored by emotion and political advocacy.

The University Can:

1. Establish structures which can initiate manage, and conduct studies that will identify technical alternatives on problems with public impact; such studies will provide invaluable educational experience for its students while at the same time serve the public interest. These structures need not become a permanent feature of the universities.

2. Allow more real-life, problem-oriented projects and case study projects to become a major element in the engineering educational program. These projects should have the active participation of faculty and students from the social sciences, law, architecture, and other fields appropriate to the project. New graduate degree programs should be created and existing programs strengthened or reoriented to include more project activity.

3. Insist that the project director seeks and obtains the full participation of faculty and students from other disciplines -- both technological and nontechnological.

4. Insure that the university reward structure encourages faculty to participate in project development as well as course and curriculum innovation.

The Government Can:

1. Insist that the engineering research and development it funds in the universities provides technical alternatives (or options).

2. Revitalize its mechanisms and increase its competence in its own sphere of

responsibility in the review and management of cooperative projects with universities. Encourage an interchange of information among engineering schools on advanced engineering development projects.

3. Make long-term funding available to universities to encourage the study and development of technical alternatives.

4. Provide long-term capitalization (analogous to the current Sea Grant Program) for technological development in the social interest.

Industry and the Engineering Societies Can:

1. Actively encourage project development at engineering schools. Establish cooperative and coordinated policies and practices that will lead to project development.

2. Encourage and support engineering that leads to the development of technical alternatives.

THE WORKSHOP PARTICIPANTS SAID ...

Establish within the individual university an administrative entity so that interested persons could address themselves to problems of significance. These interested persons would include members of the faculty, students and other members of the national and local community ... and would become involved in a 'problem centered' mode of learning.

This administrative unit would not become 'another discipline' ... but would function as a means whereby social and interdisciplinary problems could be met by appropriate members of the academic community working in cooperation with persons from the community.

The particular structural form adopted is less important in the long run than strong incentives as long as universities maintain faculty freedom of choice as a key tenet of behavior. Additionally, exceedingly important is (a) the internal reward structure, (b) graduate student administration, and (c) professional reward structure.

Interdisciplinary programs should not be regarded as a cure-all.

Create 'Technology Centers' on campuses across the country to serve as a focal point for inderdisciplinary activity among faculty and students.

Reorganization of colleges along the matrix scheme (though creating political problems) will provide a more flexible framework.

Funds should be made available to universities to make an attack on social problems. They should be given to teams of professionals rather than to individuals, because social problems, unlike theoretical problems, cannot be simplified by modeling to the point where an individual can make a significant contribution.

Universities should encourage new venture corporations to provide products and/or services in the 'social technology' area under our free enterprise, profit-motivated system.

Most of the arguments against public service responsibility hinge on the fact that the primary function of the university is education and research; public service is a serious distraction. I find that history does not support this argument.

THE WORKSHOP PARTICIPANTS SAID ...

As impartial agents, the universities should not try to solve society's problems. If they assume an advocacy role. they will undermine their own credibility which should be the cornerstone of their being.

Engineering faculties must become concerned with the outside world and lose some of their disciplinary fervor. The root of this problem is the tenure system and seems to me to be the most vexing that the universities have facing them.

The graduate professional engineering education program should have two distinct coordinates: one leading to a research career and one leading to professional practice of a problem focused nature.

Develop four- and five-year programs in public system management with initial emphasis on preparing practitioners, not researchers. Give status and incentive to such programs by awarding undergraduate stipends. It would be useful to establish regional centers at universities for research on topics related to regional needs. A major output and probably the most important would be trained graduates with new blends of professional skills.

A great deal of the engineering tradition is anti-innovative, and true innovation is not likely to be introduced until this tradition is changed.

The CASE METHOD is a teaching-learning methodology which is uniquely adaptable to the study of real world problems that are likely to be complex.

The present reward mechanism is universities favors research productivity. Evaluating research productivity and the associated prestige of research are the principal reasons for this situation.

It is recommended that the federal government provide special stimulus to the development of new socio-technological educational programs by providing three-year block grants to selected institutions of higher learning.

THE WORKSHOP PARTICIPANTS SAID ...

Decisions affecting society are made largely by politicians, influenced by public opinion, usually without regard for choice among alternatives, i.e., without technologically rational decision-making input.

There is great need for more flexibility to accommodate innovations in universities. Structures designed to protect quality can impede flexibility to innovate and this can stagnate the educational system.

I believe strongly that there is a significant need for, and major benefit to be derived from, establishment of an OFFICE OF SOCIAL DESIGN or the like in the Federal Government.

An activity, perhaps to be identified as 'Social Design' to be equal, parallel and a complement to 'research' at colleges and universities is suggested.

Improvements in old and the addition of new programs at both the undergraduate and graduate level are needed to train professionals for practice in engineering-social science fields as specialists.

In considering the kinds of activity which universities should undertake in applied socially-oriented research and public service, one helpful criterion to keep in mind might be that of 'student-centered' efforts. When the activity ceases to involve students to a substantial degree, then maybe it's time to stop the activity.

Interdisciplinary programs should be more than information gathering and information generating centers; they should also contain a public service component, involving students in field-work -- not only in technical roles, but in positions where they could also become personally familiar with the decision-making processes of government.

Not enough professors spend their sabbaticals in industry or government. There has been some foundation support of sabbaticals in industry, but the activity needs further encouragement.

More effort should be made to bring together experts from industry, government, and the universities at national laboratories or university-run laboratories to study certain problem areas on a semicontinuing basis.

THE WORKSHOP PARTICIPANTS SAID ...

There should be no bar to a student proceeding toward a doctorate, if he so desires, with his dissertation being a workable solution of a real problem in which societal aspects may be paramount considerations.

Destroy and bury forever the tenure system. The self-evident evils of such a system far outweigh the benefits.

Universities should assume a major role in anticipating the consequences of technological changes. They should be able to take the long, forward view, rather than just reacting to crises.

The student should be involved in non-structured, non-contrived (sometimes called open-ended) problems which require him to (a) ask questions, (b) define the problem, (c) identify the resources and knowledge needed to attack the problem (leading to interaction), (d) construct alternative approaches to solutions, (e) decide among the alternatives, and (f) show that the solution is an answer.

III. THE SOCIAL AND BEHAVIORAL SCIENCES EVENTUALLY MUST BECOME AS FAMILIAR TO ENGINEERING AS PHYSICS, CHEMISTRY AND MATHEMATICS.

It is as important for the engineer to learn about the public as it is for the public to understand the engineer. He must always be conscious of the social and political implications and limitations under which he operates. Furthermore, it is becoming increasingly apparent that he must learn to use the available resources of the social and behavioral sciences in his analysis and designs, even if the market for these services is not now readily obvious. Only the dedicated cooperation and interaction between engineering education and the social and political sciences can help him do this. It must start at the undergraduate level and extend through graduate studies and into continuing education.

The University Can:

1. Identify and organize resources and concepts from the social and behavioral sciences which can be incorporated into or can influence engineering design, analysis, synthesis and system specifications. Incorporate the findings of these investigations into appropriate courses in engineering curricula.

2. Insure that social and behavioral considerations are included in student design projects when these projects immediately affect people and the environment.

3. Broaden the admission standards in engineering to encourage the enrollment of students with a heightened social sensitivity or the promise of innovative ability, rather than just stressing a narrow scholastic competence.

The Government Can:

1. Support study groups specifically charged with developing concepts from the social and behavioral sciences for integration into engineering analysis and design.

2. Encourage the development of programs that will help engineering students to conceive of their own professional role in a wider context; the cultural, political, social, and economic factors related to public works, for instance, should be thought of as engineering problems.

Industry and the Engineering Societies Can:

1. Encourage the development of an engineering capability to incorporate social and behavioral consideration in analysis, design, and system specifications.

2. Increase their involvement with the universities so that students and faculty experience and learn to cope with the kind of problems that industry must face in its interaction with the public and with the community. These would include problems of communication, "image" and advertising.

3. Cooperate with government and education to create and stimulate markets for technological goods and services that are compatible with man and his environment.

4. Encourage and support continuing education programs that introduce and behavioral considerations into engineering design and analysis.

THE WORKSHOP PARTICIPANTS SAID ...

The stress on social relevance and disciplinary broadening should not obscure the continuing need for outstanding quality, style and excellence (in engineering education).

All engineers need to understand that much of their technology has contributed to the current social problems. This cannot be accomplished with a special add-a-course about engineering and society.
We suggest the development of modern curriculum materials to facilitate the rewriting of engineering textbooks and the development of case studies and scenarios. Socially oriented, interdisciplinary project courses should be available to all engineering undergraduates.

Develop pilot projects to formulate curricula which apply engineering methodologies to the social sciences. Engineers working with social scientists, perhaps using senior or graduate students, should attempt to quantify the parameters needed to model socio-technical systems and evaluate courses of action.

Engineers and physical scientists need the help and cooperation of students and faculty from action-oriented neighboring disciplines and professions. In addition, creative and innovative people from commerce, industry, and government often can provide important inputs. An advertising specialist may be able to supplement a sociologist's recommendations on how to change the attitudes of people. A building contractor may be able to pinpoint high cost operations in building construction which might be overcome by technological innovations.

We cannot think of the social engineer for the future because the need for such an individual is now. This engineer must possess an understanding of certain social sciences in order to do his job as developer of socially relevant technology.

The need for an alliance between social scientists and engineers will grow from casual to desperate as soon as we begin attacking the actual problems.

Schools with urban engineering problems should have some urban engineers who know urban life. The paucity of black engineers all but precludes this from happening today. Immediate steps are required to rectify this situation.

THE WORKSHOP PARTICIPANTS SAID ...

There seems to be some thinking in our group that the knowledge was available in the social sciences, and all we had to do was find mechanisms for getting it. It is not so. My conjecture is that much of the kinds of social science knowledge that will be usable by engineers will be developed by engineers or people who are very heavily involved in engineering even if they are not engineers. The social sciences will continue to have goals of their own in the indefinite future; there is very little an anthropologist can do for engineering today.

To solve the problems now confronting society, engineering students must master humanities and the social sciences, not as a cultural accompaniment, but as a part of their pertinent professional education. And when they go across the campus to study humanities and social sciences, they will find the faculty unequipped to present the material in a relevant form.
At this point, the engineering professor should take the initiative in teaming up with interested faculty members from the humanities and social sciences. From this alliance the ability to make a meaninfgul attack on society's problems will emerge and at the same time a body of professional knowledge will be created for the students of social engineering.

Research in engineering and related fields and in the social sciences is proceeding at many colleges and universities. Closer cooperation should be encouraged between faculty and students conducting research in these two areas. Further, joint interdisciplinary research activities should be encouraged.

Engineering education must change. Techno-social problems are not as well defined as purely technical problems. Boundaries and parameters are 'fuzzy', and algorithmic approaches may not be totally applicable in solving them.
Engineering students must be trained to deal with socio-technical problems, to deal with situations for which there is incomplete information, and to make decisions where non-technical considerations can override the technical.

Engineering colleges should seek to attract creative, unconventional, 'horizontal' minds.

THE WORKSHOP PARTICIPANTS SAID ...

Don't restrict the program to the exceptional student; readjust entrance requirements by either lowering the math and science requirements or raising the English and social science requirements.

The point I want to stress is the need to develop teaching mechanisms that will introduce engineering students to social science variables and will force them to consider these variables. This cannot be accomplished by tacking on a few relevant courses; it requires practice in working through problems in their full complexity.

THE OPPORTUNITY

In the 1950's this nation asked of technology, *"What can be done next?"* In the 1970's this nation asks, *"What should be done next?"*

As our technological society grows increasingly complex, management of the systems we create will require good judgment and high competence. Technology must benefit and not burden society. There must be a public commitment to support policies and institutions which will assure that the net effect of technological growth is in the public interest. This control is wholly within our power. If we abdicate our responsibility or neglect the task then, indeed, the complex systems and devices we create can overwhelm us.

If we have learned one thing, it is that technology cannot be divorced from the social and political life of the community. For this reason, the public must be involved in making technological decisions, decisions which will establish the role techology will play in their lives. Government, industry, universities and the public, each must work to insure that this nation will emerge with a technology that is designed to achieve the fullest and finest quality of life for all men.

APPENDIX A: DISCUSSION OF THE WORKSHOP

1. Organization and Operation of the Workshop

The problem of obtaining effective interaction and communication among the participants of the Workshop was a great challenge to the planning group. The Workshop opened with three keynote talks -- the first given by Dr. Myron Tribus; the second, by Dr. Gordon S. Brown and the third, by Professor N. Jay Demerath. The essence of their remarks is presented in Appendix E. These three speeches provided a variety of individual viewpoints which sparked discussion and controversy at the Workshop.

The participants were divided into four different groups. In order to coordinate the discussion groups along parallel paths, it was decided that each group would use as a launching platform one of the case study papers which had been previously prepared. Accordingly, one of the four topics was assigned to each group:

Group	Basis for Preliminary Discussion
Group A	Case Study on Housing
Group B	Case Study on Transportation
Group C	Case Study on Power Plant Location
Group D	Case Study on Educational Systems

The names of the participants in each of the four discussion groups appear in Appendix F. Selection for participation in a given group was made on the basis of preferences expressed by the Workshop members. Each group had among its participants a chairman, co-chairman, reporter, and a co-reporter.

One of the interesting first problems encountered was to convince the participants that the case studies were to be used as points of departure rather than as subjects for extensive study in themselves. It was intended that the groups would derive from the case studies some general socio-technical principles, as well as an awareness of the kinds of problems which almost invariably arise when society and technology interact.

At stated periods throughout the duration of the Workshop, all the participants met together and reported on the deliberations of their groups. In addition, special working sessions were held as needed, to attempt to distill and refine the findings of each of the groups. The following sections attempt to analyze the phenomena and experience of the Workshop.

2. The Phenomena of the Workshop

A. Participants' Attitudes

The Workshop, itself, undoubtedly would have provided a behavioral scientist with reams of interesting material on group interaction. The participants' variety of backgrounds, together with their strong views and impatience for progress and -- in some cases -- their natural suspicions regarding the motives of the Workshop planners, led to many interesting and spirited discussions. This is not surprising when one realizes that some engineers think *nothing* is wrong with engineering education, while some engineers think *everything* is wrong with it! Twenty-four hours after the Workshop convened, strong voices were raised questioning whether or not the results and outcome of the Workshop were not already "cast in stone". Have we been called together primarily to rubber stamp preconceived results, they wondered. Members of the Planning Committee and the Commission on Education worked hard and with some success to assure the participants that such suspicions were unfounded. In retrospect, it would seem that the difficulty in formulating substantive conclusions would be *a posteriori* evidence that there had been no preconceived results.

B. Communication -- High Noise, Low Signal

Because the participants were strong-minded individuals with impressive records of achievement, it was natural that there would be strong dissent and discord within the various groups. Often the participants became so engrossed in an idea that their thoughts would ramble far afield from a prescribed subject. However, these kinds of communication problems are to be expected in workshops of this kind; and participants should be warned to expect that the induction period will be somewhat confusing and directionless.* Also, interdisciplinary groups such as this must expect to devote their initial efforts to establishing a common vocabulary since each individual will bring with him the particular jargon of his discipline. The problems of communication which were experienced suggest that a behavioral scientist might do well to study this problem so that when future groups convene, they, by benefiting from the experience of this workshop, organize their activities in a manner which will increase both their efficiency and productivity.

C. Struggling for Innovations

Perhaps the greatest disappointment at the conference was the fact that out of all the discussions, speeches, writings, and special sessions, there appeared no startling, new, unexpected solutions. In retrospect, this probably should not have come as a surprise. There

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* A similar but much more chaotic situation was experienced at the Aspen Conference reported in "Aspen Technology Conference Ends in Chaos", by V. K. McElheny, SCIENCE, 18 November 1970, p. 1187.

are, after all, no "answers" to the problems we were posing. The Workshop clearly brought forth the fact that many of those present were engaged in their own innovative educational programs, some of which were so new that knowledge of them had not disseminated throughout the educational community. But even these innovative approaches were based on old premises. The Workshop made everyone aware of the fact that there is very little really new or innovative in education today. Any apparent newness can be attributed in most instances to new organizational schemes, new interdisciplinary involvements, new techniques, new educational technology; but no new basic principles.

This phenomenon was observed by many participants and expressed by Richard M. Zettel:*

> "Few problems are new; they are newly found or rediscovered. Sometimes situations become 'problems' because other problems, formerly regarded as more pressing, have been dealt with, with an acceptable degree of success. There is widespread belief that we can anticipate problems, weigh consequences of alternative courses of action, including the 'do nothing' alternative, and devise effective decision-making apparatus in our pluralistic society."

D. Some Conclusions

1. It is difficult to know whether or not the Workshop achieved the goals suggested by the Planning Commission. These goals admittedly were very broad, and as the Workshop revealed, they were subject to a wide variety of interpretations and prejudices.

2. The Workshop did develop certain areas of consensus, but as many participants said, there were almost all points that everyone subscribed to before the conference began. In other words, "Was the Workshop necessary to make the statements set forth in the body of this report?" Undoubtedly, yes.

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* Author of the Workshop background paper, "The Art of Transportation Planning, Circa 1970." See Appendix D.

A great deal of the wisdom in this memorandum grew out of the interactions among engineers, social scientists, educators, and behavioral scientists which took place at the conference. A great deal of reinforcement was also provided to those engineering educators who were experimenting with changes in their engineering curricula. Many of the non-technologists among the participants recognized the need for enhancing their own understanding of technology and of those who are its practitioners.

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APPENDIX D: ABSTRACT OF CASE STUDY #1

THE ART OF TRANSPORTATION PLANNING, CIRCA 1970

RICHARD M. ZETTEL
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With emphasis on the San Francisco Bay Area, problems of urban transport planning are examined. Conceptual as well as technical weaknesses are pointed out. Notwithstanding much effort doubts still exist about the future. In the Bay Area a guide rather than a plan was developed and much stress was put upon continuing planning.

The need to integrate transport planning with comprehensive planning is made apparent. Transport should be designed to improve the urban community, but the urban structure should be designed to permit mobility. None of three basic variables -- land use, transport system, or human behavior -- can be held constant. All may be manipulated in some degree to promote urban goals. Attention is given to the handicapped (for poverty or other reasons) in using current systems; and fundamental questions raised. It is asserted that urban transport systems will develop incrementally with no great technological breakthroughs likely or desirable. The main planning problem today is identification of goals in the face of elusive and shifting values. Political resolution is necessary, but can be aided by technical analysis describing total consequences of alternatives. Major barriers to progress in urban transport are to be found in institutional weaknesses rather than technological deficiencies.

Technology has a continuing role to play; it has made adjustments in the past. If engineers are to follow "social directions," however, they must develop social awareness and be prepared to deal with external consequences of their works. A multidisciplinary approach rather than "social engineering" is suggested. Engineers need to improve their ability to communicate with the public. Tailor-made courses for engineers in the social and behavioral sciences may be desirable.

APPENDIX D: ABSTRACT OF CASE STUDY #2

THE UNIVERSITY AND THE HOUSING CRISIS

D. V. RAGONE

Dean, Thayer School of Engineering
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How can universities develop mechanisms to participate effectively in housing? It is fairly easy to see that useful contributions can be made in the analysis of the technology associated with housing and the analysis of the factors that contribute to the acceptability of housing. But effectiveness implies the application of the results of these analyses to a real problem. This, for presently existing universities, will be difficult to achieve.

The contribution of the universities need not be in the form of a direct influence on housing, but rather through the exposure of their students to the problem of housing. For students seeking a direct involvement, participation in rehabilitation projects is liable to provide a useful outlet.

Rehabilitation is, by its nature, a smaller scale operation that can provide in capsule form most of the problems and challenges of new building. Plans must be made. Designs must be produced. Code approvals must be obtained. Contractors and labor must be supervised. The needs of the potential user must be considered. The difficulties and frustrations of the larger scale housing process should become quite evident in rehabilitation projects.

The attractive aspect of this type of effort for the university is that it is of manageable financial proportions. The amount of money involved or the financial exposure need not exceed a few tens of thousands of dollars. Individual rehabilitation projects with participation by students and faculty may well be the most effective way, on the short term, for universities to participate actively in the housing process.

APPENDIX D: ABSTRACT OF CASE STUDY #3

NEW SYSTEMS FOR LEARNING: HOW WE SHAPE TOMORROW'S SOCIETY

JOSEPH BERNARD MARGOLIN, Ph.D.
Director, Educational Policy Group
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Systems for learning and systems for problem solving should be approached with awareness of who the actors are and what their characteristics may be. The steps in the system and who "guards the gates" should be attended and full understanding of the dynamics of each interface as well as their contribution to the ecology of the system. In such a system the dissemination and utilization aspects will not take care of themselves yet are often left out of the problem of product design. Feedback from the user is an important ingredient in education. In this service careful attention to requirements and conditions for the operation as well as the construction of the system is important. Learners and teachers may be unpredictable consumers and creativity and learning, uncertain products. Thus we urge full attention to the motivational qualities of a system for learning or an interdisciplinary research system. It is the fuel that makes any system run.

As an aspect of policy study we highlight the importance of assessment and evaluation. If we do not systematically and scientifically pursue such a function we may be creating an even more serious crisis with the culture of Man.

Perhaps it would have been more interesting to review man's progress in space applications to education or consider the computer or ITV

more closely. We might have taken a projective look at the time when formal and informal education are no longer distinguishable or when all people can make use of a larger portion of the skills and knowledge of Man. This will come to pass but it will happen because engineers, behavioral scientists, educators and all of those involved in the development of systems for learning have successfully constructed a holistic and viable educational science responsive to the nature of man. We believe firmly that the value of hardware + software + educator + behavioral scientist + engineer is greater than the sum of its parts -- if we desire it to be so.

APPENDIX D: ABSTRACT OF CASE STUDY #4

NUCLEAR POWER AND ITS CRITICS: THE CAYUGA LAKE CONTROVERSY*

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In June, 1967, the New York State Electric Gas Corporation declared its intention to build a nuclear-fuel electric generating plant on the east shore of Cayuga Lake in New York State. Application for a construction permit was made in March, 1968, and site clearance began in April. One year later, activity on the application was postponed due to the controversy and opposition by scientists and citizens who perceived this installation, the first nuclear power station planned on a deep stratified lake, as a threat to the primary water and recreational resource of the region.

The Cayuga Lake Bell Station controversy is a case study demonstrating that the increasing need for electric power capacity conflicts with concern about the environmental effects of power generation. Many complex and widely relevant issues are embedded in that controversy. The case brings into focus relationships among scientists, public agencies, citizens' groups and policy makers and illustrates the problem of developing policy in the absence of appropriate standards and definitive scientific agreement on the character and dimensions of

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* The paper from which this abstract was drawn has since been published in a hardcover edition at $6.50 and as a paperback at $2.75 and is available from Cornell University Press, Ithaca, New York.

ecological damage. A major issue is the character of scientific evidence and its interpretation for policy purposes. What are the obligations of scientists with respect to interpretation of their data? How can inconclusive scientific data be used as criteria for policy decisions? How does the behavior of groups in opposition affect decisions concerning environmental issues? These are some of the questions raised where the siting of a nuclear power plant is under consideration.

APPENDIX D: ABSTRACT OF CASE STUDY #5

USING TECHNOLOGY TO CHANGE SOCIETY--A POLITICAL PROBLEM

BREWSTER C. DENNY

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Modern technology makes possible both goods and evils of a scope never possible before in human history. The use of modern technology to achieve these goods and to inoculate against natural disasters and against the control of the potentials for disaster inherent in many of the new technologies is principally a political, not an engineering, problem. By political is meant the political process itself and the participation of citizens in the decision-making of government, both as citizens and as public servants. The greatest challenges of the potentialities as well as the dangers of modern technology are to the political process itself, both in terms of the survival and flourishing of the fragile and noble idea of self-government, and in the capacity of the political process in the public interest to facilitate and control the introduction of technology in new ways and for new purposes into society. The high priority tasks are education of the citizenry, education of political leadership and public servants, academic research and curricular development on government policy itself, marked improvement in the social sciences, and the continued education of scientists and engineers to do their professional work with full regard to the public and human aspects of their tasks. A high priority task for engineering education is to develop more effective means of public and academic education on the realities of science and technology through, for example,

the expansion of the "Engineering Concepts of Curriculum Project"* into the college curriculum in consultation with social scientists who have personal knowledge of the public sector and public policy development. A major increase in problem and policy-oriented social science research is called for. In addressing these tasks, two dangers are noted: (1) The potential disaster that can result from the confusion about the difference between the public interest and the private sector which results from the blurring of the lines between the public and private sector caused by modern technology; and (2) That sophisticated, modern decision-making technologies, such as systems analysis and PPB, may inadvertently become substitutes for the political process itself, freezing out of participation in public decisions all but very specialized experts at decision-making itself.

*Now entitled THE MAN-MADE WORLD, this project was initiated nder the auspices of The Commission on Education before it affiliated ith NAE. Supported in part by the National Science Foundation, it was eveloped under the leadership of E. E. David, Jr., and John G. Truxal. The project is now administered at Polytechnic Institute of Brooklyn

APPENDIX E: ABSTRACT OF KEYNOTE ADDRESS #1

Myron Tribus,* Secretary for Science and Technology,
Dept. of Commerce at Opening of Workshop on Social Directions
for Technology held July 8, 1970

The keynote speaker, Dr. Myron Tribus, warned his listeners that their efforts to make engineering education more socially relevant would run headlong -- and head-on -- into the universities' historic resistance to change.

It is not, however, as important to change the curriculum and the format of engineering education as it is to change the style of engineering education, he said. The present generation of students knows how to criticize, to analyze, and to disrupt his world, but now have to build it anew. Unfortunately, engineers who have the scientific capacity to do the rebuilding traditionally feel that they are not qualified to evaluate how their technology will affect society. Traditionally, too, they resent being asked to consider the political, social, and human ramifications of the devices they design. These devices are the "hardware" of technology. The laws and institutions and people which are shaped and affected by technology are what Dr. Tribus called the "software" of technology. The next generation of engineers must be able to create "hardware" that will enhance--rather than disregard--the "software" of society.

An honest evaluation of most present-day engineers reveals that too many suffer from low (professional) self-esteem inasmuch as they feel incapable of coping with or solving the human problems that result from their technological advances. Such problems, which do not admit to solutions usually thought of as "scientific", are an anathema to most

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* Presently Senior Vice President, Business Products Group, Xerox Corporation.

engineers, who studies show, are typically disinterested in human problems; this should come as no surprise, since the "style" of their education has not prepared the engineer to bridge the gap between technology and the social sciences.

The new engineer, however, must set himself the task of dissolving the artificial separation which has too long existed between social problems and technical problems. Narrow technical competence is no longer adequate in a world that is both man-designed and man-controlled. Nor is it any longer adequate for the engineer to do only what society demands of him; he must creatively devise ways of restructuring those aspects of society which have ceased to function effectively. The engineer must help society define its needs, rather than merely waiting for society to declare its needs, rather than merely waiting for society to declare its goals.

In order to prepare the next generation of engineers for these expanded tasks, it will not be sufficient to simply inject a few liberal arts courses into the standard curriculum. New courses must be devised which will involve the student in the human problems around him, problems which his special technology makes him especially qualified to solve. It is not lawyers or politicians, for instance, who can solve the problems of pollution; only engineers--equipped to ask and answer political and social, as well as, technical questions--will be equal to this task.

If the engineer is to fulfill his new role in society, his education must convince him of his potential for creatively improving the quality of life. In order to accomplish this, Dr. Tribus urged that the

student be inspired to restructure some aspect of his immediate environment while he is still in school; but the student must be allowed to choose the problem he will tackle, rather than having an assignment imposed on him. For if engineers are to be creative, they must be educated to think and act creatively.

APPENDIX E: ABSTRACT OF KEYNOTE ADDRESS #2

Prof. Jay Demerath,* University of Wisconsin,
at General Session, Workshop on Social Directions
for Technology, Thursday, July 9, 1970

Dr. N. Jay Demerath ended his remarks with a quote from e. e. cummings: "if you and i have lips and voices which are for singing and to kiss with, who cares if some one-eyed son of a bitch invents an instrument to measure spring with?" In answer to cummings'** question, "who cares?", Dr. Demerath answered, "I care." We all must care about all the instruments which are invented because they affect the way we live.

Dr. Demerath affirmed the necessity for forging links between technology and the social sciences, but he warned against the folly of trying to make every engineer a self-monitoring renaissance man. Because the majority of engineering students come from lower middle class backgrounds, they are for the most part highly career-oriented and determined to achieve swift upward mobility, goals which are inconsistent with the kind of visionary idealism that the engineer-humanist will need. Instead, our efforts must be concentrated on the training of a distinct and uniquely endowed cadre of "social engineers".

In order to attract such unique individuals to careers in

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* Presently Executive Director, American Sociological Association.

** N. B.: e. e. cummings is quoted as he himself would write, i. e., in lower case.

engineering, entrance requirements must be radically altered. Schools of engineering must open their doors to liberal arts students who have had virtually no background courses in engineering. Such students will require and will demand a specailly designed course of instruction. Adding a few social science courses to the existing curriculum will not suffice. To train a cadre of engineers who are equally sensitive to social as well as technological problems, new kinds of inter-disciplinary programs will have to be developed; this will necessitate recruiting a new kind of faculty, as well as new kinds of students.

Such an interdisciplinary program (which might be called the Department of Social Engineering) will, it is hoped, train experts who will have the ability to analyze political and social problems--such as housing--with the specialized techniques that engineering training affords.

Having trained this special cadre of "social engineers", it will be necessary to induce the engineering profession, as well as private industry, to hire them. Those who do the hiring will have to be convinced that the viewpoint of the "social engineer" is an essential component in the solution of almost all engineering problems.

APPENDIX E: ABSTRACT OF KEYNOTE ADDRESS #3

Dr. Gordon S. Brown, Massachusetts Institute of Technology,
at General Session, Workshop on Social Directions
for Technology, Thursday, July 9, 1970

Dr. Gordon S. Brown reaffirmed his belief that the universities have a public service responsibility to be involved actively in solving society's problems. The university cannot be merely a custodian of history, aloof to the convulsive changes going on around it; rather, it must become an instigator of soundly conceived change. Scholars are especially qualified to identify social wrongs and to rectify them; society must have access to the unique resources they represent.

There was a time when the doctrine was widely accepted that it was the universities' job to educate and the government's job to act. But, now, when society is changing at a convulsive rate, we cannot afford the luxury of the ivory tower. In the past, it was enough for the university to provide basic research data and to hope that the data would be utilized intelligently. But, today, the communications media, which cause us to see wars, poverty and injustice as they happen, have created a clamor for swift and relevant action within the once cloistered halls of the university.

It is important, however, that the university not be consumed

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* These remarks formed the basis of an article written by Dr. Brown, entitled The Challenge of Relevance, which was published in TECHNOLOGY REVIEW, October/November, 1970, Massachusetts Institute of Technology, Cambridge, Massachusetts.

by the revolution it helps to instigate. Society is changing at an hysterical rate; the university must not be caught up in this hysteria, but must instead respond to change with wisdom and detachment. The future of society may well depend on whether or not the university is willing to accept this new responsibility for public service.

Just as the university has to expand its realm of activity, so engineers must expand their area of concern. The engineer can no longer isolate himself in his laboratory and develop his hardware. It has become compellingly obvious that each new system creates new social problems. Technological developments precipitate social problems; our system of education must reflect this interaction.

In order to restructure the format of engineering education, we must find common denominators between the sociologist and the engineer. Mission-oriented programs which involve students in activities beyond the boundaries of the classroom provide such a common denominator. Such problems as urban decay, environmental pollution, demands for energy, food shortage, social unrest, and the population explosion lend themselves to the mission-oriented approach which allows professors from diverse disciplines to participate in the solution of a single problem.

Future engineers must be aware of the social aspects of each new system they devise. For example, when new materials (automobiles, refrigerators) are created, the problem of their ultimate disposal must be considered. But the problem is even more complicated than

this, because as soon as one admits the need for social change, one must first decide on the priorities for change (which changes are most urgent). As one begins to "solve" technological problems, one creates new social, political, economic, and educational problems. For instance, our refined communication techniques have had a vast impact on the social and political fabric of society (an example: the privacy of the individual has been severely threatened by progress in communication techniques.) Similar conflicts exist between the curtailment of crime and the freedom of the individual, between health care and the exploding population, between the need for more housing and the already over-taxed transportation systems and waste disposal systems, between the need for increased cultural, religious, and recreational facilities and the need for new industry.

The university must devise new methods for resolving these conflicts. It must come to terms with its responsibility for new and expanded forms of public service.

APPENDIX F: COMPOSITION OF EXECUTIVE GROUPS

	GROUP "A"	GROUP "B"	GROUP "C"	GROUP "D"
	Boeing	Communications	Power Plant Piping	Educational Systems
Chairman:	Alvin R. Convenes	William W. Baldwin	David J. Bean	Kenneth C. Fiske
Co-Chairman:	Kyle F. Kelley	Joseph L. Mulcahy	E. Jay Zemanick	Alvin W. Drake
Reporter:	Stephen E. Tarasenko	Dwight H. Eastman	Dorothy Gibbs	Charles A. Wainwright
Co-Reporter:	Charles E. Smith	Richard A. Smithmoe	A. David Bonnin	David C. Miller

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